Signal Characteristics

$X(t)$ ≡ a signal a voltage $V(t)$ or current $i(t)$ which is a function of time

Assume $X(t) = V(t)$

Gross Parameters — dc level & rms value

dc level V_{DC}

$$V_{DC} = \lim_{T\to\infty} \frac{1}{T} \int_{\alpha}^{\alpha+T} V(t)\, dt$$

α is any real no.

rms ≡ root mean square

rms level V_{rms}

$$V_{rms} = \sqrt{\lim_{T\to\infty} \frac{1}{T} \int_{\alpha}^{\alpha+T} V^2(t)\, dt}$$

If $V(t)$ is periodic with period T

$$V_{DC} = \frac{1}{T} \int_{\alpha}^{\alpha+T} V(t)\, dt$$

$f = \frac{1}{T}$ ≡ frequency

$$V_{rms} = \sqrt{\frac{1}{T} \int_{\alpha}^{\alpha+T} V^2(t)\, dt}$$

Mead

Example 1 $\quad v(t) = A \sin \omega t \quad \omega = 2\pi f \quad f = \frac{1}{T}$

$$V_{DC} = \frac{1}{T} \int_0^T A \sin \omega t \, dt = 0$$

$$V_{rms} = \sqrt{\frac{1}{T} \int_0^T A^2 \sin^2 \omega t \, dt} \quad , \sin^2\theta = \frac{1}{2}[1 - \cos 2\theta]$$

$$= \sqrt{\frac{1}{T} \int_0^T \frac{A^2}{2} [1 - \cos 2\omega t] \, dt} = \frac{A}{\sqrt{2}}$$

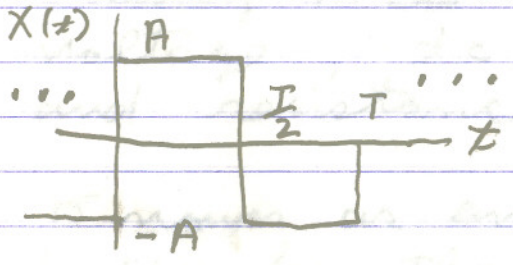
Example 2 $\quad v(t) = V_0 + A \sin \omega t$

$$V_{DC} = V_0$$

$$V_{rms} = \sqrt{\frac{1}{T} \int_0^T [V_0 + A \sin \omega t]^2 \, dt}$$

$$= \sqrt{V_0^2 + \frac{A^2}{2}}$$

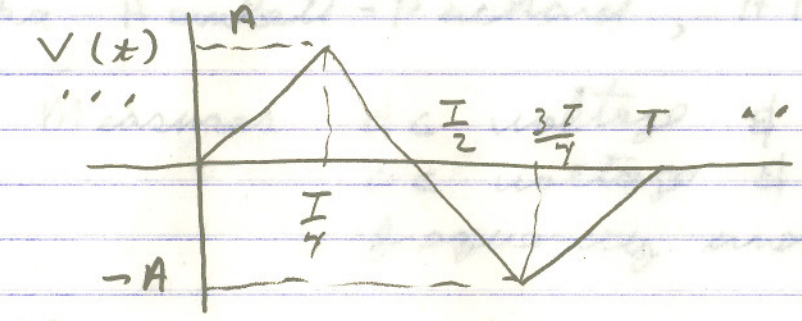
Example 3 $\quad$ Square Wave



$$V_{DC} = 0$$

$$V_{rms} = A$$

Example 4 Triangular Wave



$V_{DC} = 0$

$V_{rms} = \frac{A}{\sqrt{3}}$

Electronic Test Instruments

Oscilloscopes — Measure and Display signals as functions of time and/or frequency

Meters — Measure and Display gross parameters of signals V_{DC} & V_{rms}

Instruments { Analog — User Digitizes
Digital — Instrument Digitizes

Meters used in ECE 3041:

* Simpson Meter Model 260-7 AMM

Analog Meter that measures dc voltage, dc current, ac voltage, and resistance. AMM ('Analog Multimeter)

It reads as an averaging meter since it provides the correct rms value only if the ac waveform is a sine wave with no dc level

* Agilent 34401A Digital Multimeter
aka Hewlett-Packard, HP or Dip DMM

Measures dc voltage & current
ac voltage & current
frequency and resistance

Measures correct ac or rms voltage
for any waveform. Displays 6 ½ digits.

* Fluke 73 HHDMM - Hand Held
digital multimeter. Display 3 ½ digits.

* National Instruments ELVIS
Electronics Laboratory Virtual
Instrumentation Suite.

Oscilloscope & DMM
Also Function / Arbitrary Waveform
Generator, LCR meter, etc.

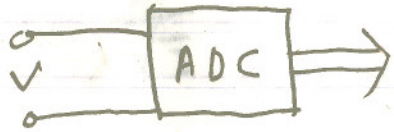
DAQ Board & Workstation

Analog Meters

Current causes a pointer to
move across a calibrated scale



Digital Meter



digital code

Oscilloscopes are required to examine the wave shape or fine structure of a signal.

For instance, to determine the crest factor of a signal an oscilloscope is required.

Crest Factor ≡ the ratio of the peak value to the rms value of a signal

Example 1 Sine Wave $V(t) = A \sin \omega t$

$$CF = \frac{A}{\frac{A}{\sqrt{2}}} = \sqrt{2}$$

Example 2 $V(t) = V_0 + A \sin \omega t$

$$CF = \frac{V_0 + A}{\sqrt{V_0^2 + \frac{A^2}{2}}}$$

Example 3 Square Wave

$$CF = \frac{A}{A} = 1$$

Example 4. Triangular Wave

$$CF = \frac{A}{\frac{A}{\sqrt{3}}} = \sqrt{3}$$